BioMAP Report SWR-2

Ministry of Environment and Energy
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ENVIRONMENTAL ASSESSMENT OF THE TEESWATER RIVER AT THE VILLAGE OF TEESWATER, BRUCE COUNTY

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Executive Summary

This report documents significant nutrient, organic and bacterial enrichment occurring in the Teeswater River. Field observations establish the presence of nuisance plant and algae growth through approximately a 2 km section of stream downstream from the Highway 4 bridge in the Village of Teeswater, Bruce County. Bacterial slime growth was observed fouling the cooling water and boiler blow-down discharge pipes from the Gay Lea Foods Cooperative Limited. These growths covered the entire stream bottom for approximately 500 m downstream from the Highway 4 bridge. Water sampling documented elevated nutrient, BOD_5 and suspended solids levels being discharge from the Gay Lea Foods Cooperative Limited sewage treatment plant. Bacterial sampling defined significant bacterial loadings gaining access to the Teeswater River from the Gay Lea Foods Cooperative Limited discharges and the Teeswater storm sewer system. Biological data characterize an aquatic community typical of impaired water quality conditions. Water quality entering the village of Teeswater is impaired (nutrient enriched) from upstream land use practices. Additional water quality impairment occurs within the village of Teeswater and extends at least 2 km downstream.

Introduction

The village of Teeswater is located at the intersection of Highway 4 and County Road 16 in Culross Township, Bruce County. The 1988 population was 976. This village relies on private sewage systems and has no municipal sewage treatment. A storm sewer network discharges to the Teeswater River. Gay Lea Foods Cooperative Limited is the major dairy processing industry in Teeswater. The company has a sewage treatment plant and at least two other point source discharges to the Teeswater River.

Residents of the Village of Teeswater have displayed increasing concern regarding the quality of water in the Teeswater River. The Ministry of Environment and Energy has received public complaints about inadequate private sewage systems, contaminated storm sewer discharges, and industrial discharges.

The purpose of this report is to assess the water quality of the Teeswater River in the vicinity of the town of Teeswater and to identify the source(s) of any impacts.

Materials and Methods

To assess the water quality of the Teeswater River, 4 macroinvertebrate sampling sites were established. These sites were numbered from 1 through 4, with Station 1 being furthest upstream and Station 4 located furthest downstream (Figure 1). All 4 sites were sampled between July 19 and 28, 1993. Standard "Bio MAP" sampling procedures were used for this study (Griffiths 1993). Two quantitative (Surber) samples and one qualitative (bucket and sieve) sample was collected at each site. The Surber samples were located adjacent to each other with Surber 1 closest to the right bank and Surber 2 closest to the left bank (facing downstream). A 600 µ mesh net was used on the Surber samplers. The qualitative samples were 30 minutes in duration. The benthic samples were transported to the Ministry of Environment and Energy in London in 2 L jars. The samples were live picked, sorted, identified and preserved in 80% ethanol.

Water quality is the ability of water to support aquatic life. Benthic macroinvertebrates (bottom-dwelling organisms) were used to assess water quality because these organisms are known to require specific environmental and habitat conditions to survive and reproduce. Since

these organisms are subjected to the full rigor of the local environment throughout their life cycles, which may vary from weeks to years, they reflect historical conditions and not solely those conditions at the time they were sampled. By understanding these requirements, one can translate the composition of the benthic community into water quality terms.

Chemical and bacteriological sampling sites were established at each biological site and at 3 additional point sources, labelled A, B and C (Figure 2). Water samples collected on July 26 were analyzed for BOD_5, ammonia, total Kjeldahl nitrogen, nitrite, nitrate, total phosphorus, dissolved reactive phosphorus, pH, conductivity, chloride, turbidity, fecal coliforms, fecal *Streptococcus*, *Pseudomonas aeruginosa* and *E. coli*. Water samples collected on July 28 were additionally analyzed for suspended solids, COD, dissolved organic carbon, calcium, magnesium, hardness, sodium, potassium, alkalinity and colour. These samples were analyzed at the Ministry of Environment and Energy Regional Laboratory in London.

Storm sewers in Teeswater were not discharging flows to the river and could not be sampled on July 26 or 28.

Visual observations of plant and algae growth were made throughout the study area. Photographs and a short video were taken at each sampling site to document existing site conditions. Water temperature and conductivity were measured in the field. A large section of the River downstream of Site 3 was walked, and observations were noted. Downstream from Highway 4, filamentous slime growth was collected for identification. A Magellan global positioning system (GPS) was used to determine the UTM co-ordinates of each biological sampling site.

Results

Field Observations

The Teeswater River at the village of Teeswater is a medium sized stream which has transitional, fast flowing, clear, cool to warm waters and is 8 to 14 m in width. Water depths throughout this section of stream range between a few cm in riffle areas to 1 m in pools. Average depth in runs (between riffles and pools) is approximately 0.5 m under base flow conditions. The

bottom of the river is composed of rocks, cobble, gravel and sand, which are characteristic of glacial spillways.

At Site 1, the substrate was fairly clean. There was sparse diatom growth and *Cladophora* stubble on the larger cobble and rocks which were moderately silted. The water was very clear with no odour. On July 26, the water temperature was 23° C and the conductivity was 490 μmho/cm^3.

At Site 2, siltation was minimal and the water was clear and odourless. On July 26, the water temperature was 23° C and the conductivity was 495 μmho/cm^3.

Site 3 supported nuisance growths of the filamentous bacteria *Sphaerotilus*. Severe siltation occurred in areas of dense vegetation and bacteria growth. The water was clear but had a foul, sour odour. On July 28, the water temperature was 23° C and the conductivity was 500 μmho/cm^3.

At Site 4, aquatic vegetation growth was luxuriant and siltation was minimal. On July 19, the water temperature was 19° C and the conductivity was 420 μmho/cm^3.

Macroinvertebrates

Macroinvertebrate densities at Site 1 were found to be approximately 410 organisms per 0.09 m^2 of river bottom (Table 1). A total of 33 taxa were found representing a wide range of taxonomic groups (caddisflies, mayflies, true flies, amphipods).

An extremely high degree of variation between the 2 quantitative samples at Site 2 was noted. The density of macroinvertebrates at site 2-1 (i.e. Surber 1 located along the right bank) was an order of magnitude greater than at site 2-2 (i.e. Surber 2 located along the left bank). Hydropsychid caddisflies, *Baetis flavistriga*, blackflies and orthoclad midges mainly accounted for the greater macroinvertebrate density. Macroinvertebrate density at site 2-1 was the highest observed in the study area.

Midge at Site 3 accounted for about 76% of the macroinvertebrates, a far greater proportion of the benthos than at the other sites (Figure 3). *Diamesa*, which was common as Site 1, was

absent and apparently replaced by the midges *Stictochironomus* and *Paratarytarsus* The density and richness of mayflies was dramatically lower in comparison to the other sites.

The taxa richness at site 4 was higher than at the other sites. The variety of leeches and molluscs found at this site was mainly responsible for the higher richness.

Macroflora

There were no rooted plants at Site 1, however there was sparse *Cladophora* stubble and some moss and diatom growth on the larger rocks (Figure 4). At Site 2, below the STP discharge, watercress was present along the stream margin and healthy growths of moss were present in the riffles (Figure 5). At Site 3 dense beds of the macrophytes *Elodea* and *Potamogeton* were noted in riffle areas. Nuisance growths of *Cladophora* appeared just upstream of site 3 and continued downstream for at least 2 km. Frond lengths averaged approximately 4 - 5 cm at Site 3 and increased in length to more than 200 cm at Site 4. At Site 4, large mats of *Cladophora*, drifting from upstream, were accumulating in nearshore areas, rocks and bridge abutments. Rooted aquatic plants (*Elodea* and *Potomogeton*) were well established in this area.

Sewage Fungus

Severe growths of sewage fungus, the bacterial slime *Sphaerotilus*, originated from the cooling water and boiler blowdown pipes discharging water into the river from Gay Lea Foods Cooperative Limited. These discharge pipes were located on the north side of the river, between County Road 16 and Highway 4. The greyish-white slime growths fouled the inside of the discharge pipes and fouled the river bottom downstream of these discharges in a defined plume along the north side of the river (Figure 6). Complete fouling of the river bottom with bacterial slime occurred in the vicinity of the Highway 4 bridge. The stream substrate, including algae and rooted plants, was completely fouled with a layer of bacterial slime for a distance of approximately 500 m downstream of the Highway 4 bridge (Figure 7).

WaterChemistry

Chemistry of the discharges from Gay Lea Foods Cooperative Limited (sites A, B, C) varied greatly between days (Tables 2 and 3). Except for nitrate, chemical concentrations were much greater on July 28 than July 26. Significant inputs of phosphorus, BOD_5, and suspended

solids from the STP discharge (Site A) were measured on July 28 (Table 3). Furthermore, samples from the cooling water and boiler blowdown pipes, sites B and C, revealed BOD_5 levels of 18 and >14.8 mg/L, respectively.

Bacteria

Bacterial concentrations varied greatly between the two sampling dates (Tables 2 and 3). On July 26, *Pseudomonas aeruginosa*, a disease causing pathogen, was present in the sewage plant discharge (site A) and from the cooling water discharge (site B). Significant bacterial contamination was evident in the cooling water.

On July 28, extremely high bacterial concentrations were found in all the Gay Lea Foods Cooperative Limited discharges (Table 3). The sewage treatment plant discharge contained fecal coliform concentrations of 11,600,000 / 100 ml. The cooling water contained 390,000 fecal coliform bacteria /100 ml. The presence of *Pseudomonas aeruginosa* was found in all discharges from Gay Lea Foods Cooperative Limited. The higher concentrations of bacteria measured in the river downstream of the Gay Lea Foods was a direct result of these discharges.

Discussion

The macroinvertebrate composition (mainly caddisfly, midge, amphipods) at Site 1 represents the background conditions upstream from the Village of Teeswater and is typical of an agriculturally stressed stream system (nutrient enrichment). If no further stresses are imposed on the river than this community would be expected to occur throughout the study area .

The high density of macroinvertebrates (2428 organisms per sample) at site 2-1 relative to site 1 suggests that the STP discharge is rich in organics and nutrients. The increased density of midge and caddisfly noted at Sites 2-1 is typically a direct response to organic enrichment; hydropsychid caddisflies construct nets to filter out organic particles on which they feed. The high density of macroinvertebrates at site 2-1 relative to site 2-2 suggests that the plume from the STP stays along the north side of the river for some distance.

The virtual elimination of mayfly nymphs at Site 3 and the replacement of *Diamesa* with the more pollution tolerant midges, *Paratarytarsus* and *Stictochironomus*, indicates a significant

stress on the aquatic community. Midge (*Chironomidae*) populations dramatically increase at Site 3 likely as a result of the great abundance of the sewage fungus, *Sphaerotilus*, which creates a more suitable environment for midge (Phaup 1968). The occurrence of *Sphaerotilus* also indicates poor water quality conditions. *Sphaerotilus* grow as chains of cells enclosed in tubular sheaths and colonize all submerged surfaces. It is a very long, fine, filamentous, slime producing bacteria which, when healthy, is usually white in colour. *Sphaerotilus* is typically found in rivers below sources of organic pollution. It often thrives downstream from treated and untreated domestic sewage, and untreated industrial effluent, particularly food and drink industries (Curtis 1969). *Sphaerotilus* thrives best in a continuous source of nutrients. The oxygen consumption of this nuisance bacteria can be 10 to 20 times greater than that of other normally occurring macrophytes. *Sphaerotilus* easily sloughs off and drifts downstream. Drifting *Sphaerotilus* may reattach and continue growing, or may accumulate in pool areas where it decomposes and produces a foul odour. In bloom proportions, it dominates the substrate and smothers fish eggs and aquatic fauna. Commercial and sport fishing can be affected by the fouling of nets and lines (Curtis 1969).

The dense, luxuriant beds of *Elodea* and *Potomogeton* which occurred at site 3 and downstream (Figure 8) are indicative of eutrophic conditions. These plants require abundant nutrients (namely phosphorus) and require clear waters to exist. The nuisance growths of *Cladophora* observed at site 3 and downstream (Figure 9) also indicate enriched water quality conditions. *Cladophora* is a filamentous green alga that thrives in nutrient rich waters. It frequently reaches nuisance proportions downstream of intensive agricultural areas and nutrient rich discharges. Unlike *Sphaerotilus*, it requires sunlight and a solid substrate to thrive. As a result of increased photosynthesis and respiration by *Cladophora*, severe oxygen fluctuations occur daily. During the decay phase oxygen demand increases, thereby creating additional stress to aquatic organisms. Dense *Cladophora* growth dominates the substrate and causes siltation as water velocity is reduced through thick mats. *Cladophora* blooms most often occur as a result of human activity and can cause severe alterations to the previously existing aquatic habitat (Westwood and Johns 1992).

The primary source of nutrients for the macrophytes and algae is most probably the STP, whereas the source of organic carbon for the sewage fungus is the STP and the discharges from the cooling water and boiler blow-down pipes. The STP discharge is not acceptable. Phosphorus, biological oxygen demand, and suspended solid concentrations must be reduced. Similarly, discharges from the cooling water and boiler blow-down pipes are not acceptable. The biological

oxygen demand concentrations suggest that these effluents contain waste waters, otherwise the BOD_5 would likely be less than 1 mg/L.

Significant bacterial contamination was also evident in the discharges from Gay Lea Foods Cooperative Limited. *Pseudomonas aeruginsoa* was consistently present in high numbers in these discharges. This pathogen is not normally found in surface waters and when present, poses a significant health risk to humans and animals (livestock). *E. coli* concentrations were also very high. This bacteria is characteristic of human and mammalian wastes and typically indicates the presence of human disease-causing pathogens.

The composition of the benthic community at Site 4 is similar to Site 1, and reflects nutrient enriched conditions. The greater richness in species such as clams, snails, beetles, crayfish and amphipods likely reflects the wider range of habitats available at this location. The occurrence of macrophytes and *Cladophora* suggests that this site is more enriched than site 1. The lack of sewage fungus indicates that conditions have recovered from those at site 3.

Water quality is impaired at all the study sites. No toxic conditions occur as evidenced by the existence of the abundant aquatic life throughout the study area. The existing communities are representative of nutrient and organically enriched water quality. A decline in water quality from Site 1 conditions is evident at sites 2 and 3. The benthic community at Site 4 suggests recovery and is approaching background (Site 1) conditions.

Storm Sewer Sampling

A storm sewer discharge enters through the flood plain at Site 3, on the south side of the river (Clinton Street sewer). No flows were discharging to the river from this source during the study period. Flows, however, are typically in the range of 40 L/min from this source (L. Struthers, MOEE Owen Sound). Storm sewers were sampled by Larry Struthers five times from June through September 1993. The water sample analysis from this sampling effort document the presence of undertreated domestic sewage in the discharges. The bacterial levels are significant, with *Pseudomonas aeruginosa* levels high in July and August (600 - 1300 per 100 ml). *E. coli* bacteria were present in all samples with levels ranging between 1500 and 1,100,000 per 100 ml. *E. coli* are indicative of human waste sources. The Clinton Street sewer is a significant source of bacteria to the river downstream from Site 3.

Nutrient levels were elevated in the discharges from the Clinton Street sewer. Phosphorus levels of 2.5 and 2.9 mg/L were recorded in August and September of 1993. Nitrate and ammonia levels were surprisingly low relative to phosphorus and BOD_5 levels. The elevated nutrient levels, although intermittent, promote the growth of rooted aquatic plants and algae downstream from Teeswater.

The Teeswater River and a number of storm sewers were sampled on September 29, 1993, during a rainfall event. The presence of *Pseudomonas aeruginosa* is significant in almost all samples including the control sample upstream from Teeswater. High *E. coli* numbers in these samples indicative of domestic waste sources.

Recommendations

1. The Gay Lea Foods Cooperative Limited should immediately address the control of nutrients, organics and bacteria from their processing facility in the village of Teeswater. To protect water quality in the Teeswater River, phosphorus levels from the sewage treatment plant should be less than 0.5 mg/L during the growing season and 1.0 mg/L or less during the winter. BOD_5 and suspended solids levels should not exceed 15 mg/L. Discharges from the plant during ice-free periods (May to November) should not have *E. coli* concentrations exceeding 200 per 100 mL and *Pseudomonas aeruginosa* exceeding 0 per 100 mL.

2. The sources of *Pseudomonas aeruginosa* and *E. coli* in discharges from the storm sewers should be specifically located and source of the problem defined. Elimination of these sources are required since they represent a health risk to water users downstream from Teeswater.

3. Sources of agricultural impact upstream from Teeswater should be identified and the agricultural community encouraged to use best management practices for farm waste and conservation methods to protect soils

Acknowledgements

We would like to thank Dr. Ronald Griffiths, who provided consultation on taxonomic identifications and interpretation of biological data throughout the study. We are also grateful to Annie-Claude Bosse, who assisted in collecting field data.

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Table 1: Density (number per 0.09 sq. m) of benthic macroinvertebrates at 4 sites along the Teeswater River, July 1993. Samples 1 and 2 represent individual Surber samples while Q denotes a 30-min qualitative sample.

	Site 1			Site 2			Site 3			Site 4		
SAMPLES	Q	1	2	Q	1	2	Q	1	2	Q	1	2
Insects:												
ALDERFLIES:												
Sialidae:												
Sialis	P			P		1						
BEETLES:												
Elmidae:												
Optioservis	P	5	3	P	10	6	P		14	P	8	
Stenelmis	P		3	P	92	8	P	1	11	P	16	
Hydrophilidae:												
Helophorus										P	2	
Laccobius										P	2	
Psephenidae:												
Ectopria										P	2	
Psephenus				P	1							
BUGS:												
Corixidae:	P			P								
Palmacorixa				P			P					
Gerridae:												
Gerris				P								
Rheumatobates	P	1		P								
CADDISFLIES:												
Glossosomatidae:												
Glossosoma				P	1							
Protoptila	P		1	P	2	1						
Helicopsychidae:												
Helicopsyche							P		1	P		2
Hydropsychidae:												
Cheumatopsyche	P	66	120	P	604	49	P	39	96	P	50	61
Hydropsyche	P	46	95	P	404	29	P	66	153	P	76	100
Hydroptilidae:												
Hydroptila	P		3	P	63	10	P	33	7	P	8	44
Limnephilidae:												
Neophylax	P	12	19				P	1		P	171	224
Pycnopsyche	P			P			P			P		
Philopotamidae:												
Chimarra				P	4	1						
Psychomyiidae:												
Psychomyia	P	26	15	P	5	2	P		2	P	1	

Table 1: continued.

	Site 1			Site 2			Site 3			Site 4		
	Q	1	2	Q	1	2	Q	1	2	Q	1	2
MAYFLIES:												
Baetidae:												
Baetis flavistriga	P	2	44	P	199	49	P		4	P	12	23
Pseudocloeon			3	P	8					P		
Heptageniidae:												
Stenonema				P								
S. femoratum	P									P		
S. interpunctatum	P	4		P						P		
S. mediopunctatum	P									P		
S. pulchellum	P									P		
Tricorythidae:												
Tricorythodes	P		1	P			P	3		P	2	3
STONEFLIES:												
Perlidae:												
Acroneuria	P	1		P	1		P					
TRUE FLIES:												
Atheridae:												
Atherix				P	3		P	8	8			
Chironomidae:												
Glyptotendipes										P		5
Microtendipes	P	35	16	P	11		P		31	P	33	47
Polypedilum	P	5	4	P	80	2	P	113	121	P	10	30
Stictochironomus							P	15	8			
Tanytarsini	P	2	3	P		1	P	53	39	P	2	
Paratarytarsus				P	6		P	90	55	P	6	44
Diamesa	P	9	7	P	72							
Pagastia	P	9	12	P	36	3	P	30	20	P	5	3
Orthocladiinae	P	6	25	P	514	23	P	540	410	P	17	47
Corynoneura	P	1	1				P		8			
Pentaneurini	P	2	2	P	6	1	P		4			
Simuliidae				P	159	16	P	10	11	P	4	13
Tipulidae:												
Antocha	P	87		P	32	8	P	24		P	33	
Crustaceans:												
AMPHIPODS:												
Gammaridae:												
Gammarus	P	88	30	P	116	7	P	44	28	P	43	172
Talitridae:												
Hyalella azteca										P	8	101

Table 1: continued.

	Site 1			Site 2			Site 3			Site 4		
	Q	1	2	Q	1	2	Q	1	2	Q	1	2
CRAYFISHES:												
Astacidae:												
Orconectes				P			P	4		P		
Orconectes virilis										P		1
Molluscs:												
CLAMS:				P								
Sphaeriidae:										P		
Musculium lacustre										P		
Pisidium	P			P			P			P		
Sphaerium							P			P	6	
SNAILS:												
Ancylidae:												
Ferrissia							P					
Hydrobiidae:												
Amnicola										P		
Lymnaeidae:												
Lymnaea	P											
Physellidae:												
Physella	P							2			3	
Physella gyrina							P	2		P	3	
Physella integra				P						P		
Planorbidae:												
Gyraulus										P		
Helisoma anceps	P									P		
Valvatidae:												
Valvata tricarinata										P		
Annelids:												
LEECHES:												
Glossiphoniidae:	P											
Glossiphonia complanata										P		1
Helobdella stagnalis										P		
Erpobdellidae:												
Erpobdella punctatum										P	2	1
WORMS:												
Tubificidae	P	5					P			P		1
TOTAL ORGANISMS		412	407		2428	217		1077	1029		525	923
TAXA RICHNESS	33	20	20	38	24	18	32	19	20	47	26	20

Table 2: Water chemical and bacteriological characteristics at 4 sites along the Teeswater River (Sites 1-4) and effluent from the sewage treatment plant (Site A) and cooling water discharge (Site B) from Gay Lea Foods Ltd. on July 26, 1993. All measurements expressed in mg/L unless otherwise stated.

Variables:	Sampling Sites					
	1	A	2	B	3	4
BOD5	0.80	0.50	0.60	0.40	0.40	0.50
Turbidity (NTU)	7.17	6.85	NA	NA	5.71	2.52
Ammonia	0.018	0.065	0.017	0.114	0.024	0.007
Total Kjeldahl Nitrogen	0.480	0.78	0.49	0.26	0.47	0.50
Nitrite	0.02	0.10	0.01	< 0.01	0.01	0.02
Nitrate	2.8	10.9	2.9	0.5	2.6	2.7
Total Phosphorus	0.014	NA	0.019	0.011	0.020	0.060
Dissolved Reactive Phosphorus	< 0.001	0.800	< 0.001	0.001	< 0.001	0.027
Chloride	9.7	26.0	8.0	3.1	8.0	9.5
pH	8.36	7.57	8.36	7.61	8.28	8.70
Conductivity (µmho / cm3)	525	786	526	589	521	495
Fecal Coliforms /100 ml	300	30	80	> 1 000	300	140
Fecal Strep. /100 ml	170	> 1 500	500	150	640	180
Pseudomonas aeruginosa /100 ml	<4	28	<4	8	<4	<4
E. coli /100 ml	240	<10	36	> 1 000	260	120

Table 3: Water chemical and bacteriological characteristics at 4 sites along the Teeswater River (Sites 1-4) and effluent from the sewage treatment plant (Site A), cooling water discharge (Site B) and boiler blowdown discharge (Site C) from Gay Lea Foods Ltd. on July 28, 1993.
All measurements expressed in mg/L unless otherwise stated.

Variables:	Sampling Sites						
	1	A	2	B	C	3	4
BOD5	1.20	72.00	2.80	18.00	> 14.8	2.40	1.82
Suspended Solids	14.8	77.0	7.4	7.6	16.4	6.9	5.2
COD	9	280	11	15	49	13	8
Turbidity (NTU)	3.40	25.30	3.09	0.79	4.48	2.68	1.50
Ammonia	0.017	0.880	< 0.005	< 0.005	< 0.005	< 0.005	0.005
Total Kjeldahl Nitrogen	0.51	13.00	0.67	0.80	1.55	0.74	0.59
Nitrite	0.01	0.07	0.01	< 0.01	< 0.01	0.02	0.02
Nitrate	2.7	< 0.1	2.9	< 0.1	< 0.1	2.6	2.4
Total Phosphorus	0.017	13.800	0.069	0.190	0.660	0.143	0.084
Dissolved Reactive Phosphorus	0.016	10.80	0.048	0.019	0.032	0.054	0.013
Dissolved Organic Carbon	3.2	62.5	3.5	7.9	17.9	3.5	3.0
Calcium	70.1	73.8	68.9	78.8	67.0	69.7	67.7
Magnesium	28.0	27.7	27.4	28.8	24.6	27.2	27.6
Hardness	291	299	285	316	269	286	283
Sodium	3.6	230.0	4.5	7.3	51.7	6.2	6.6
Potassium	1.7	70.7	2.0	1.5	1.4	2.3	2.3
Alkalinity	260	712	266	247	250	266	257
Chloride	8.2	76.3	9.0	4.6	4.1	9.2	10.5
pH	8.27	7.79	8.30	7.31	7.53	8.10	8.65
Conductivity (μmho / cm3)	539	1680	544	613	716	561	520
Colour (TCU)	15.5	92.5	16.5	5.0	7.5	15.0	16.0
Fecal Coliforms / 100 ml	500	11600000	96000	390000	39000	84000	460
Fecal Streptococcus / 100 ml	300	2 400000	100000	5300	3800	100000	40000
Pseudomonas aeruginosa / 100 ml	<10	1600	12	44	180	44	< 4
E. coli / 100 ml	500	9600000	76000	160000	17000	52000	340

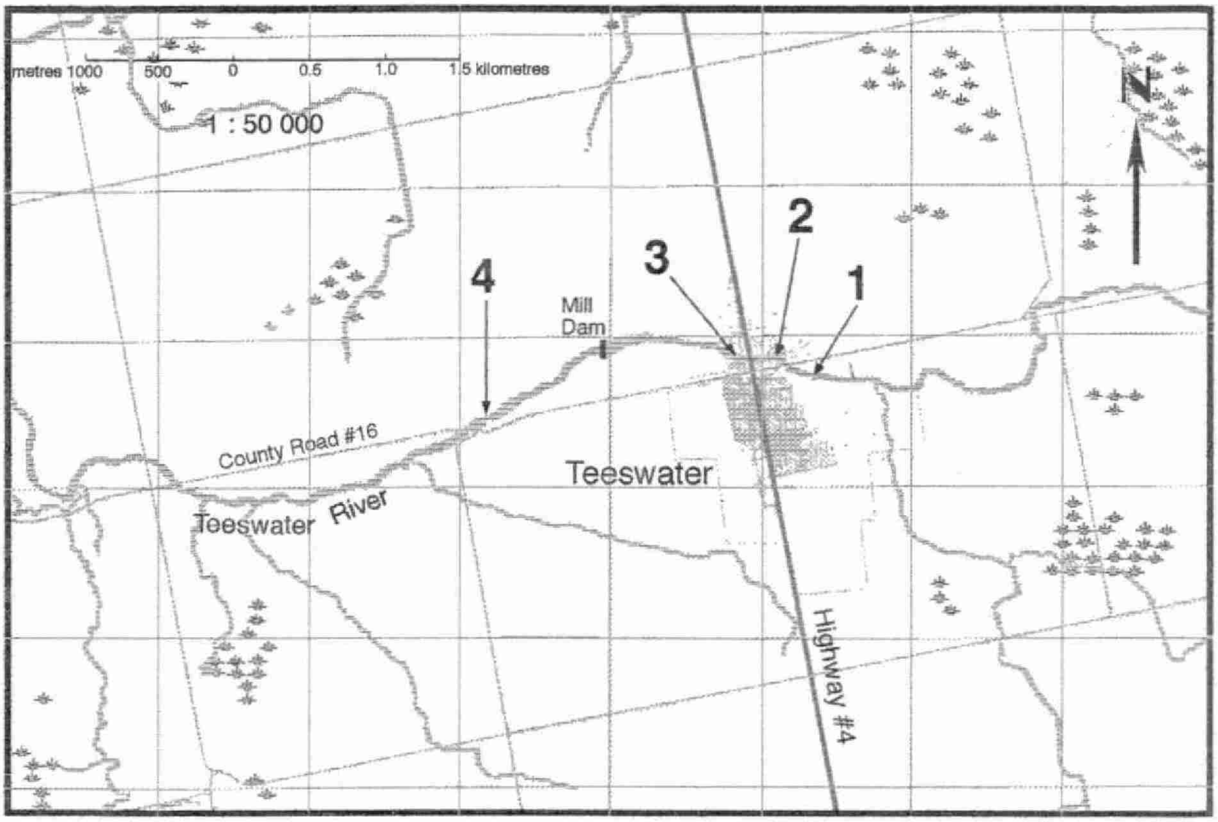

Figure 1: Location of biological sampling sites along the Teeswater River, July 1993.

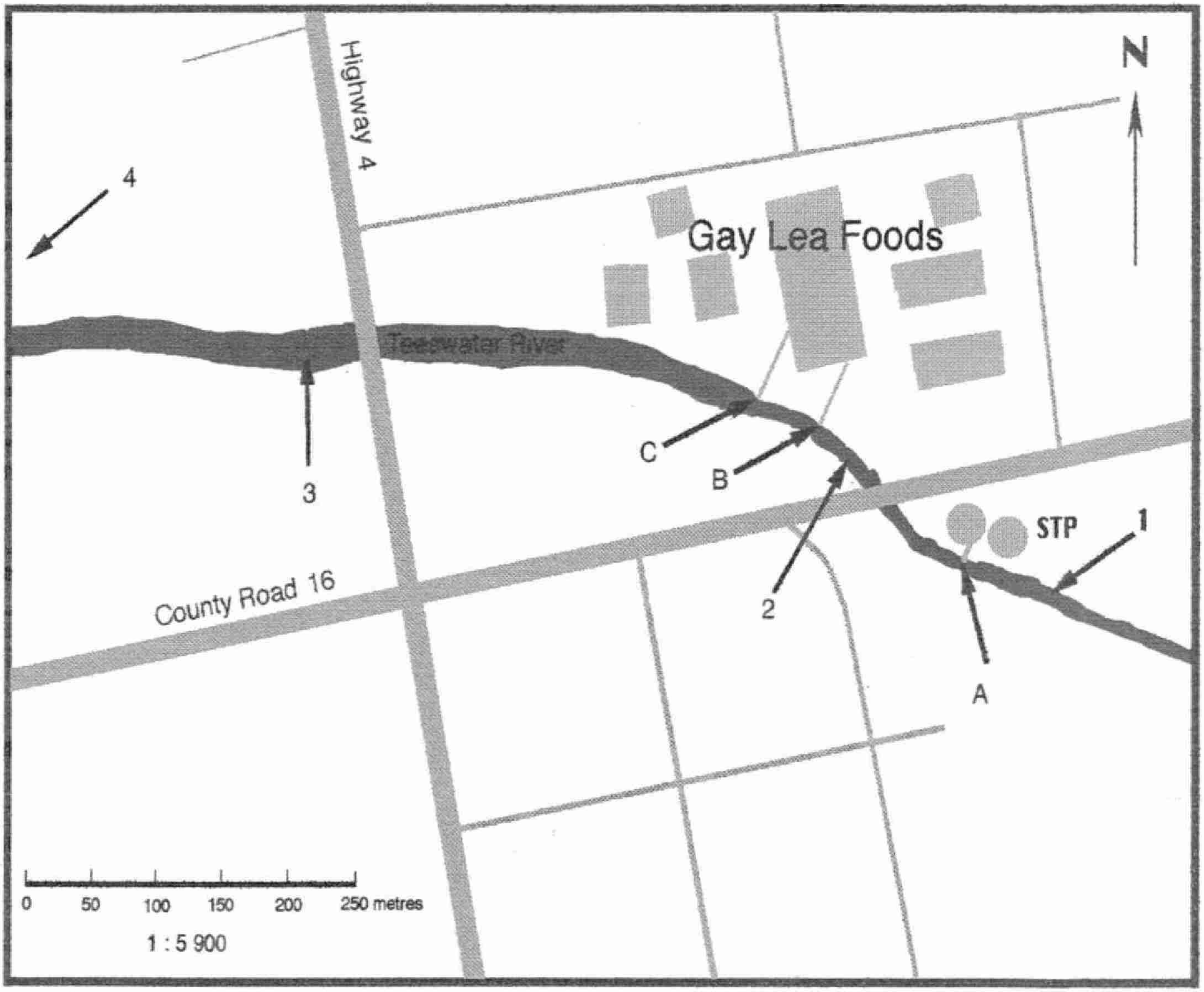

Figure 2: Location of chemical and bacteriological sampling sites along the Teeswater River, July 1993.

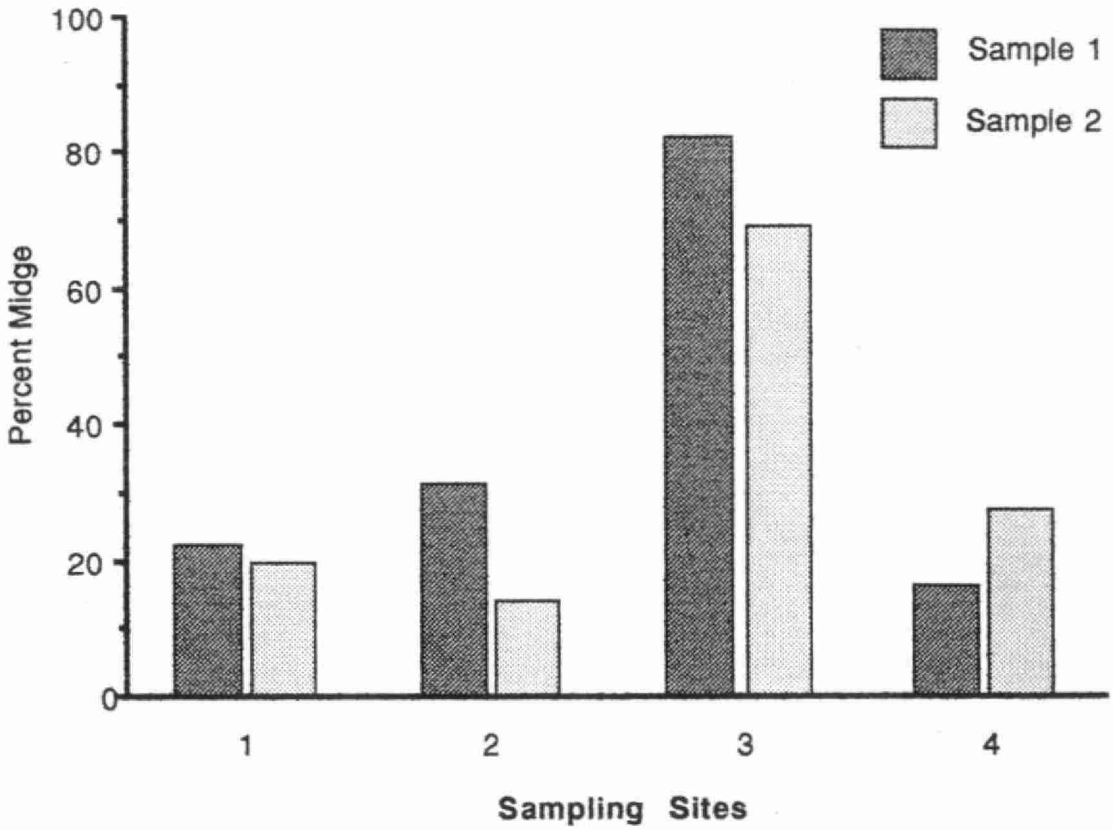

Figure 3: Relative abundance of midge in samples at the 4 sites along the Teeswater River.

Figure 4: Substrate at biological sampling Site 1 (upstream control).

Figure 5: Substrate at biological sampling Site 2.

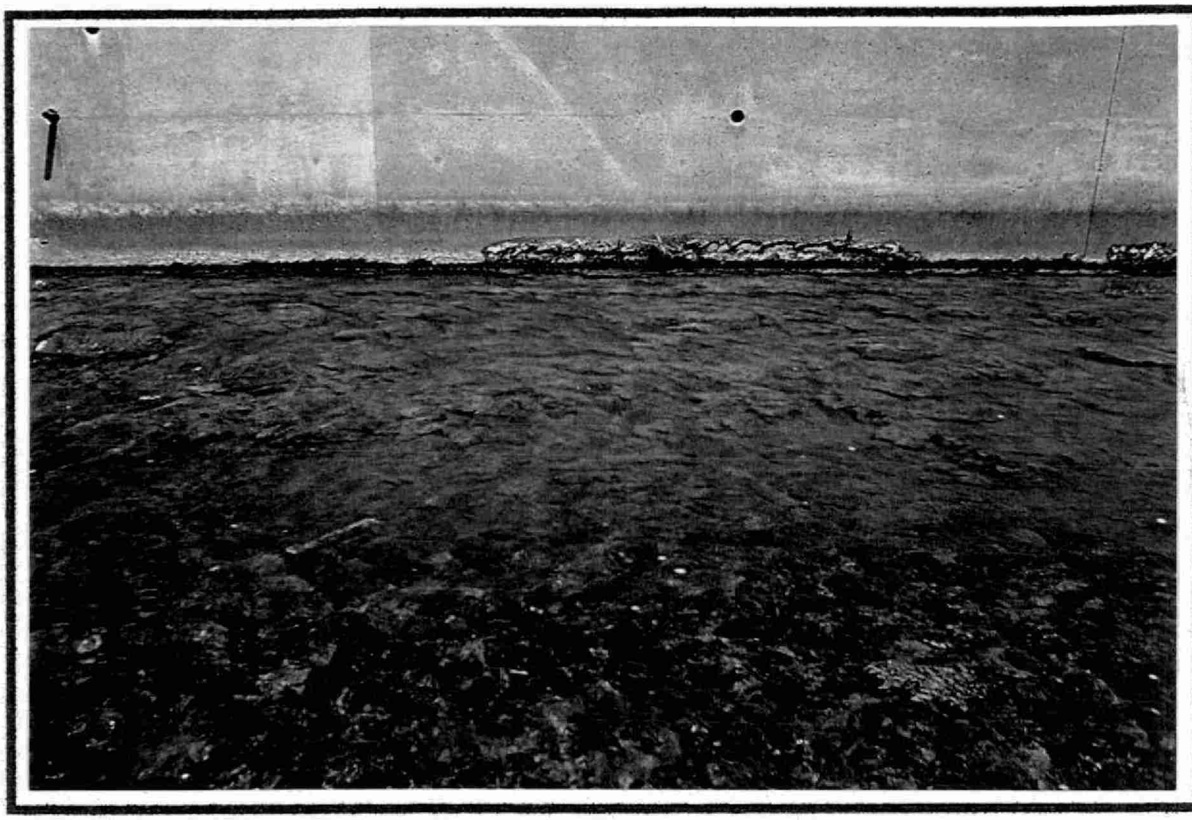

Figure 6: Substrate downstream of Gay Lea cooling water discharge. The opposite side of the river is fouled with *Sphaerotilus*.

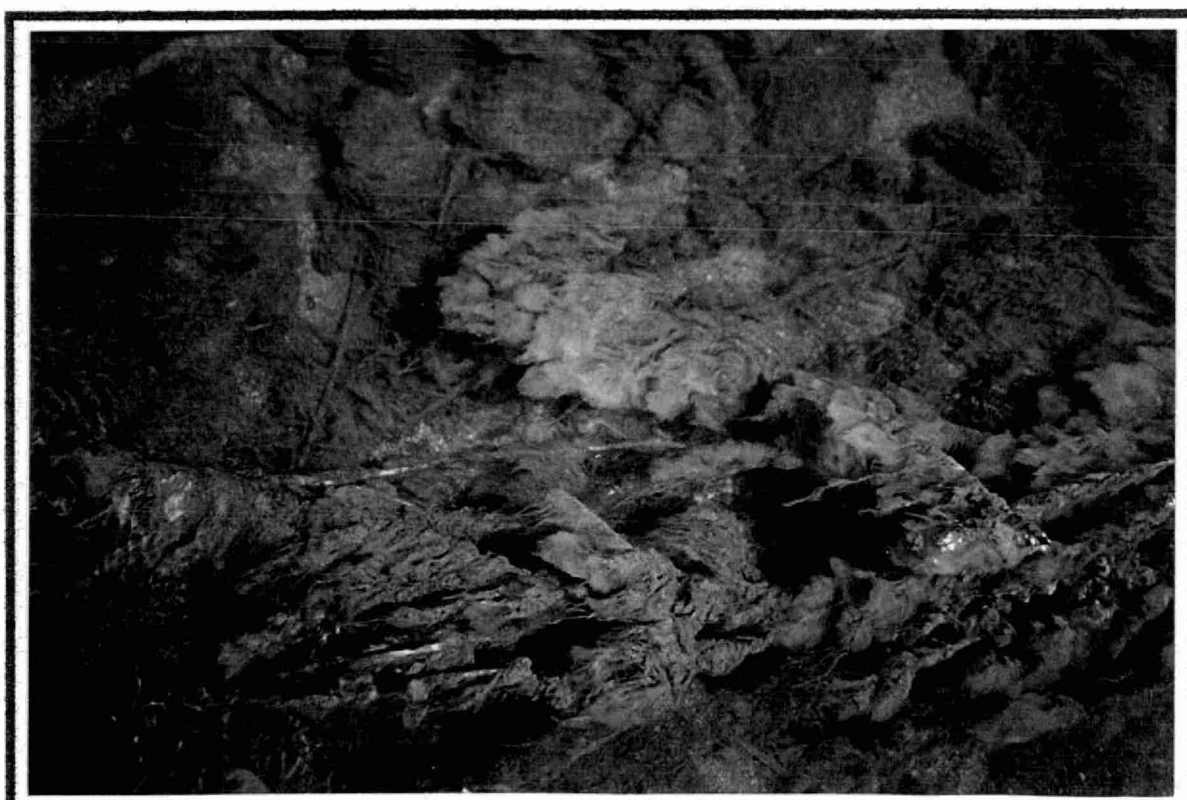

Figure 7: Substrate at biological sampling Site 3 fouled with *Sphaerotilus*.

Figure 8: Profuse Macrophytes between biological sampling sites 3 and 4.

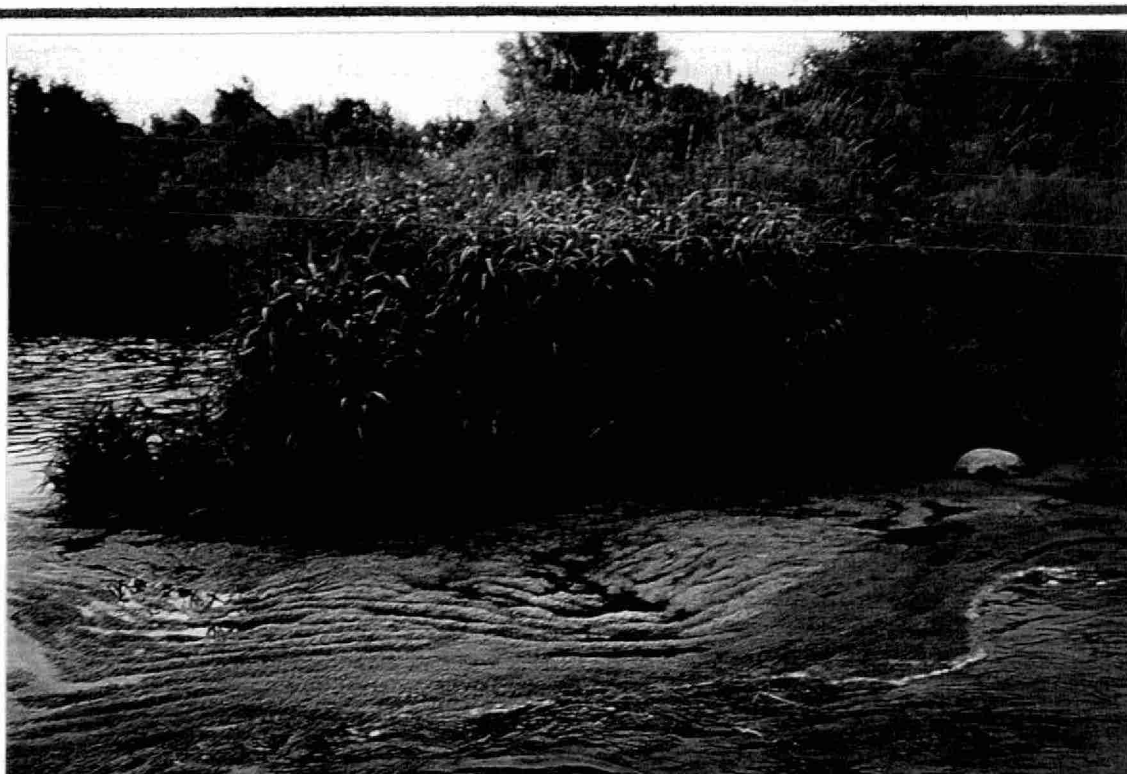

Figure 9: Large mats of *Cladophora* at biological sampling Site 4.